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The Gold Measures of Nova Scotia and Deep Mining.

BY

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(GEOLOGICAL SURVEY OF CANADA.)

TOGETHER WITH

OTHER PAPERS BEARING UPON NOVA SCOTIA GOLD MINES.

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INTRODUCTORY.

Nova Scotia Gold Fields.

By E. GILPIN, Jr., M.A., L.L.D., F.R.S.C., Etc., Inspector of Mines.

The gold fields of Nova Scotia became known about the year 1860.

The earliest discovery was followed by numerous others, until it was at first believed that it was all auriferous. Gradually, however, it became evident that the workable deposits of free gold were confined to the Atlantic half of the Province. Investigation showed that this district was occupied by two divisions of rock, granite and slates, and quartzites or sandstones, compacted by a silicious cement, and locally known as "whin." Geologists referred the latter to the Lower Cambrian age, a series of rocks known to be auriferous in other parts of the world.

In Nova Scotia they are divided into the lower or quartzite group, and the upper or ferruginous and graphitic slate group The lower group, to which a thickness of over 11,000 feet is assigned by Mr. Faribault, consists principally of quartzite, interstratified with numerous beds of slate varying in colour and texture, and with a few beds of compact conglomeritic rock. The upper group, which is over 4,000 feet thick, is almost wholly composed of bluish black soft slates.

By the labors of Mr. Faribault, the pioneer of the Geological Survey in the mapping of the gold fields, much detailed information has been collected, and I am indebted to him for his clear presentation of the most interesting facts relating to the stratigraphy of the rocks under consideration.

These measures, originally horizontal, have been moved by a powerful and uniform pressure from the south, exerted in a line roughly parallel to that of the coast, which has folded them into a series of sharp parallel undulations or folds. By denudation these folds have been so worn down that in a generally level country they have been extensively exposed in horizontal sections, showing within a few hundred yards the reverse dips, to the north and to the south. The rocks generally dip at an angle of 75° to 90°, seldom lower than 45°, and overturns are frequently noted.

Following the definition of the extent of the gold fields of the province as given by the early writers, it would be put down at about 6,500 square miles. Various deductions have been made from this on account of the granite masses which are frequently met. The granite is of an age, roughly speaking, geologically referred to a period later than the Devonian.

Generally the estimates allow that about one half of the auriferous district is occupied by granite, making the extent of the gold fields about 3,000 square miles. The granite is presented in masses and dykes of varying shape and size, and appears, broadly speaking, to have melted through the slates and quartzites. The granite is not generally considered to be auriferous, although gold has been found in quartz veins in it at points far distant from the slates and quartzites.

The upper or slate group is not recognized by miners as auriferous, although quartz veins occur in it, and sometimes show gold. It may be found, however, on further examination, that at favorable localities extensive deposits of low grade ores are presented in it.

Attention has therefore been confined principally to the lower or quartzite group. From Mr. Faribault's observations it appears that the gold belts occur at a distance below the base of the upper or slate group, varying from 2,800 to 8,000 feet, giving a thickness of about 5,000 feet of auriferous strata. Veins occur at other points in the lower group of rocks, but have not yet been found to be pronouncedly rich in gold.

It will, therefore, be seen that wherever this section of the lower group has been folded, denuded and exposed, there the best fields are opened for exploration and work. Eleven of these auriferous anticlinals have been defined between Sheet Harbor and Caledonia. There are many others succeeding these, starting from the shore and passing obliquely away from it. The district to the eastward of Halifax has been carefully mapped by the Geological Survey, and the courses of these auriferous anticlinals laid down approximately between the points where they are known exactly by mining operations. These maps are on a scale of one mile to the inch, and give minute topographical details, so that the localities where prospecting can be most advantageously carried on are readily observed. In order that information may be available as to the district lying west of Halifax, Professor Bailey has examined in less detail, the counties of Lunenburg, Queens, Shelburne and Yarmouth. In these districts there are larger quantities of granite, but the same general structure is preserved. The maps and reports relating to the gold fields are invaluable to gold miners, and can be obtained by payment of nominal prices from the office of the Canadian Geological Survey at Ottawa.

The quartz veins of Nova Scotia occur in these anticlinals intercalated between the layers of quartzite and slate as beds running parallel with the strata. They are seen to turn on their course where the anticlinal axis has become depressed, and underground operations have shown them rising up on one side and dipping down again on the reverse side, without a break in their continuity, or giving any surface indication of their existence. They extend in many cases for thousands of feet, and have been followed to depths of seven hundred feet in their vertical extension. In size they vary from an inch up to twelve or fifteen feet, many of the most productive are from six to fifteen inches in thickness. They present in spite of their bedded position, many of the characteristics of typical veins. Their essential ingredient is quartz, varying in texture and color ; in many of the more productive veins presenting a smooth surface and

bluish shade. There is always present a varying percentage of iron, copper, lead and zinc sulphides and traces of other minerals. Cross or fissure veins also occur at Rawdon, Caribou, Blockhouse, Oldham, Brookfield, etc., and are frequently productive.

The gold is present characteristically in the free state as irregular masses, varying from microscopic particles to irregular patches, often several ounces in weight. It is also present in films covered by the metallic accompaniments, and as invisible particles in them. There are also quartz veins almost free from sulphides, etc., yielding gold in workable amounts, although it is not visible. But little attention has yet been paid to this class of veins, unattackable by the ordinary quartz mills, although adapted for chemical treatment by the more modern systems. In the veins the gold is sometimes distributed with comparative uniformity over considerable areas; usually, however, it is more or less concentrated within certain defined limits, leaving spaces on each side comparatively barren. These enriched zones are known as pay streaks, are repeated in some veins, and follow certain laws not yet clearly understood. They have hitherto been the principal source of the gold production.

Gold is also found sparingly in the quartzite beds and more abundantly in the slates. The latter when in contact with the quartz frequently show it in thin platings, and the small veinlets of quartz seaming the slates often carry gold. When one or more quartz veins occur in connection with a slate bed, the whole bed is frequently rich enough to be worked as a low grade ore. As will be shown further on, practical experience has taught the miner that profitable low grade ore means material yielding in an ordinary stamp mill from two dollars to the ton and upwards. The continuity of the anticlinal axes are broken at some points by faults of great extent: smaller faults are met in the veins, but considering the age of the strata, they are unusually uniform and free from disturbance.

The Gold Measures of Nova Scotia and Deep Mining.

By Mr. E. R. Faribault, B.A.Sc., Geological Survey of Canada.

The gold measures of Nova Scotia became known about the year 1860. The earliest discovery was followed by so many others, that it was believed that the whole of the Province was auriferous. Gradually, however, it became evident that the workable deposits of free gold were confined to the metamorphic rocks of the Atlantic coast, along which they form a continuous belt, from one end of the province to the other, a distance of some 260 miles, varying in width from ten to seventy-five miles.

They cover about half the superfices of the province, exclusive of Cape Breton Island, and their extent may be roughly estimated at 8,500 square miles. Of this area, probably 3,500 square miles are occupied by granitic masses, barren of gold, leaving an area of about 5,000 square miles of gold-measures.

The granite intersects the stratified gold-bearing rocks, in many places, in large masses or dykes, but for the most part it forms a prominent ridge, almost unbroken, from one end of the province to the other. Its intrusion took place at the close of the Silurian period, probably about Oriskany, and was accompanied and followed by disturbances, faults and much local metamorphism of the stratified rocks. It occurred after the folding of the gold-measures and the disposition of the quartz veins ; for granite dykes and veins have been observed to always cut the interstratified quartz veins wherever they come in contact with them. The granite has thus no relation to the auriferous character of the veins, and need not again be referred to.

Although, no well defined fossils have so far been found in the sedimentary rocks constituting the gold-measures, most geologists agree to classify them, provisionally, as Lower Cambrian.

They certainly, in many respects, resemble the auriferous Cambrian of the Eastern Townships of Quebec, and knowledge gained in the Nova Scotia gold-fields may prove of the greatest practical importance in prospecting for veins below the alluvial deposits of Quebec.

The gold-measures of Nova Scotia fall naturally into two well defined and distinct groups, viz., a lower or "quartzite group" and an upper or "slate group."

The mapping of the eastern part of the province, by the Geological Survey, places the thickness of the quartzite group, as far as denudation has exposed these rocks to view, at about three miles, and the thickness of the upper or slate group, at about two miles, giving a total known thickness of strata of over five miles.

The lower division or quartzite group is mostly composed of thick-bedded, bluish and greenish grey felspathic quartzite, locally named by miners "whin," a term used in Scotland for an igneous rock or greenstone. Interstratified with the quartzite are numerous bands of slates, of different varieties and colors, from a fraction of a foot to several feet in thickness. The upper division or slate group is mostly composed, east of Halifax, of bluish-black slate, often graphitic and pyritous, rusty-weathering, with occasional layers of flinty quartzose rock. The lower part of this group is characterized by greenish, argillaceous and chloritic, soft slate, of but little thickness at the east end of the province, but increasing to a greater thickness at the west end. A few layers of magnesian, siliceous limestone have also been noticed at different places, at the base of the group, overlying conformably the quartzite of the lower division. The line of division between the two groups is thus well defined by characteristic bands, which form valuable data to work out the

sequence and structure of these rocks, at any point, with certainty.

The beds of quartzite and slate, forming the gold-measures, were originally deposited in the sea, and therefore horizontally. These horizontal beds were then subjected, during a long period of time, to forces that have produced prodigious results. A close study of the present structure of these rocks shows that they have been slowly moved by a powerful and uniform pressure, which has folded them into a series of huge sharp undulations, roughly parallel with the sea coast. They have indeed been buckled, bent and folded to such a degree that they occupy only one-half of their former width, measured at right angles to the strike.

Since these rocks were deposited and folded they have been under the unceasing influence that tend to level the hills and fill up the valleys, and, at more recent date, the greater part of the surface was subject to glacial erosion. Extensive denudation has worn away the folded measures to the present level. Some of the sharpest and highest folds have been truncated to a depth, as far as we know, of over eight miles, exposing at the surface a section of gold-measures of over five miles in thickness.

The map (Fig. 2) is a reduction of map-sheets published by the Geological Survey on the scale of one mile to one inch. It represents a portion of the gold-measures, thirty-five miles wide and sixty miles long, east of Halifax, between Musquodoboit Harbor and Sherbrooke. The black lines show the anticlinal axes of eleven folds, into which the measures have been plicated; the narrow, dark shadded bands indicate remnants of the upper slate group, left undenuded along the deepest troughs or synclinal axes of the folds, the other areas indicate the granite masses.

A diagram (Fig. 3), gives a section of thirty-five miles in length, drawn across the whole belt of the gold-measures, along the line of section A B in the plan (Fig. 2.)

Below (Fig. 3) is given, for comparison, a diagrammatic section of the Bendigo gold fields of Australia, on a scale ten times as large as the one above, The heavy black lines indicate

gold mines on four different anticlinals, worked on the line of section.

The amplitude of the folds, or the distance between the different main anticlinal axes in these two gold fields respectively, varies considerably. The Nova Scotia section of thirty-five miles gives eleven anticlinals, or an average distance of three miles between each anticline, and a maximum distance of nearly five miles; while in Bendigo gold district, it ranges from 300 to 1,300 feet. So that in Nova Scotia, the amplitude of the folds is nearly twenty times greater than in Bendigo.

The mapping of the gold-measures by the Geological Survey during the last fifteen years, has been extended, under my charge, as far west as Lunenburg. The study of the structure of these rocks, over that region, has afforded an opportunity of acquiring many important facts and data by means of which gold mining may be carried on with more confidence, under more exact conditions, and with greater economy.

The most important feature disclosed, is that all the rich veins and the large bodies of low grade quartz worked in Nova Scotia, with few exceptions, follow the lines of stratification, and occur at well defined points along the anticlinal axes of the folds.

It was during the progress of the slow folding of the measures, that the rich quartz veins and large saddle-lodes of quartz were formed, at favorable places, along the planes of bedding on the anticlinal domes of the folds.

Thus a thorough knowledge of the structure of the anticlinal fold becomes necessary, to locate the auriferous quartz deposits on the surface, and to develop them in depth.

In tracing the axes of the folds at the surface, the dip of the rocks is the chief guide. If the strata are found to dip towards each other, it is clear they form a synclinal axes or trough; while, if they dip in opposite directions they form an anticlinal axis or ridge.

The rocks, on opposite sides of the anticlinal axes, generally dip at angles varying between forty-five and ninety degrees

from the horizon, seldom lower than forty-five degrees, and overturned dips are frequently noted.

The deviation of any bed from the horizontal, along the axial line, is its "pitch." A longitudinal section, made east and west along the axis of an anticlinal fold, will show the strata and the fold to pitch either to the east or west, at low angles, seldom over thirty degrees from the horizon.

Owing to the pitch the outcrop-edges of the beds, on each side of an anticline, are not parallel to the axial line; if they converge towards the east, the anticlinal fold dips east, and if to the west it dips to the west.

When the pitch inclines both ways from a central point, that point is the centre of an elliptical "dome," and marks the position of one of the most favorable points on the main anticlines for the occurrence of quartz veins.

The average distance between one dome and the next, along the same anticlinal axis, varies from ten to twenty-five miles.

It has been thought by some, that these domes were caused by gentle north and south undulations, crossing the sharp east and west folds. Such does not, however, appear to be the case, generally, as it can clearly be seen by looking over the geological maps of the region, that the pitch at corresponding points on the various main anticlines is often quite different.

It will be seen that most, if not all, of the gold mining centres operated are situated on these domes.

Moreover, it has been observed that most of the anticlinal domes, upon which mines are not in operation, show indications of gold, and many will eventually prove to be important auriferous centres, only a few of them being without the structure necessary for the formation of quartz veins.

Of the twenty-one domes, in the region covered by this map (Fig. 2) fourteen have been worked more or less, six have shown auriferous quartz in situ or in float, and the remaining one has not yet been proved.

The gold districts operated to the east of Halifax are here given, together with their horizon or the distance of their strata

below (and in one case above) the base of the upper slate group.

Moose River	about 3¼	miles
Tangier	" 2¾	"
Fifteen-mile Stream and Beaver Dam	2½	"
Lawrencetown	2	"
Goldenville, Harrigan Cove, Gold Lake and Forrest Hill	1½	"
Waverley and Renfrew..........................	1¼	"
Mooseland, Killag, Liscomb Mill, Richardson, Lower Isaac's Harbour, Wine Harbour and Montague..	1	"
Ecum Secum, Middle Isaac's Harbour, Cochran Hill, Lake Catcha and Oldham	¾	"
Salmon River..................................	½	"

Caribou at the base of the Slate Group.
Stewiacke about ¾ mile above the base of the Slate Group.

There is no doubt that certain kinds of slate are more favorable to the segregation of gold than others, and that the prevalence or absence of the former, at certain horizons, will necessarily give zones of different richness.

The fact that important mines have already been worked at different horizons, from the top of the series to the bottom, is sufficient proof that strata favorable to the formation of auriferous veins are met with throughout the whole thickness of the lower quartzite group, and perhaps also in the upper slate group, though apparently les frequently. This is an important fact with regard to deep mining on the domes of anticlines.

The manner in which the strata are bent over the axial lines is worthy of note. The strata in folding do not bend round a centre, to form circular curves, but their curves are more like parabolas, superimposed upon one another. This is due to the immense lateral pressure which has compressed these beds, especially the slate bands, on either side of the fold, producing a thickening of the strata and openings between them on the apex of the folds.

In a certain thickness of sheets of paper or cloth, bent into an anticlinal fold, a "slipping" of the several layers on each other will take place: the sides of the fold will be tightly compressed, while, on top, openings will be formed. In the same manner in the folding of this great thickness of strata, the beds separated along the planes of stratification, and moved along

these planes, the upper bed sliding upward on the lower inclined bed.

This slipping is clearly proved by the striations and slickensides that are to be seen in most mines on opposite bedding planes, and by a certain thickness of crushed black slates or gouge between the walls.

Such movements naturally took place between strata, where the cohesion was slightest, and thus, we find quartz veins following layers of slate, especially when the slate is intercalated between thick beds of hard qnartzite.

These slips may be considered as fault-fissures along bedding planes, and it is along these fissures that the quartz began to be deposited. and, as usually, these movements were very slow and intermittent and extended over the whole period of folding, the quartz was also deposited very slowly, usually in thin coatings accumulating one over the other, as the fissures widened, until veins of different thickness and extent were formed. The quartz often holds minute scales of slate, peeled oft the walls, and subsequently covered over by other layers of silica, giving a banded structure to the veins; while the gold also often occurs in streaks parallel with the banded structure.

The large-scale plans made during the last two summers by the Geological Survey, including the most important districts to the east of Halifax, have brought to light important facts bearing on the relations of the structure of the anticlinal domes to the thickness, extent and auriferous streaks of the quartz veins.

In the case of sharp anticlinal domes, such as those of Salmon River, Mooseland, the Richardson mine, Fifteen-mile Stream and others, where the dip of both legs of the anticline forms an angle of less than forty or forty-five degrees, large bodies of quartz, called "saddle reefs" in Victoria, are found to occur along the anticlinal axes, and to bend comformably with the bedding.

On the course of the anticlinal axes, the saddle reefs generally keep their size for a great distance, pitching with the strata both ways from the centre of the dome, and eventually pinch

out at a certain limit, which may be called the limit of the formation of quartz on the axial line.

They also curve sharply and follow the strata on the north and south dips, but generally thin out much more rapidly on the legs than on the pitch. Many legs have been mined in Nova Scotia to the depth of several hundred feet, and the quartz has still been found of a fair width. In Bendigo, where the folds are on an average, twenty times smaller than in Nova Scotia, the legs of quartz are said to very seldom extend to greater depth than one hundred feet below the cap of the saddle reefs : which would correspond proportionately to 2,000 feet in Nova Scotia.

These saddle reefs in Bendigo, are not only of great size and and of remarkable persistence in length, but are also notable for recurring in depth, one below the other.

At the Lazarus mine, Bendigo, there are from the surface to the 2,200 foot level, no less than twenty-four of these saddle reefs, thirteen of which are auriferous to a payable degree, and some of great size.

At Bendigo, on the 31st Dec., 1897, six mines were worked over 3,000 feet in depth, and twelve over 2,700 feet: the deepest, the Landell's, 180 mine, was down 3,352 feet, and these were all worked on anticlinal folds.

No operation has yet been carried to any depth, through the arch-core of the folds in Nova Scotia, but the important developments done along the anticlinal axes at Salmon River, the Richardson mine, Waverley, Oldham and Mooseland, should be sufficient to convince the most sceptical, that quartz saddle-reefs and legs may be found underneath one another, to even a greater depth than in Bendigo.

The Montreal-London Gold and Silver Development Co., largely composed of Montreal capitalists, which acquired lately the Dufferin mine at Salmon River, is at present sinking on the dome of the anticlinal fold a vertical shaft, with cross-cuts and levels, which has reached a depth of over 300 feet. I am glad to call the attention of the meeting to this development, which may be considered the first important step in the introduction of

a new system of mining, and will, no doubt, be the inauguration of a new era of extensive and permanent deep mining in Nova Scotia.

Few reliable data can be obtained regarding the relative richness of the different parts of the saddle reefs and legs on a sharp fold, but many veins, worked on the apex of the fold, such as the Richardson lead at Isaac's Harbor, the Dufferin lodes at Salmon River, and the Bismarck lead at Mooseland, show that the vein is richer or can be worked with more profit on the saddle than on the legs.

In the case of a broad fold, when the angle formed by the dips on both sides of the anticline is over forty-five degrees, the veins do not acquire any great development along the axial lines, and the enlargements are found rather at a certain distance from the axis.

The thickness of the strata denuded, chiefly since the folding, has already been shown to be very great, reaching on some anticlines eight miles. This superincumbent mass of rock exerted a powerful pressure which has to be taken into account in the folding process. It is evident, that in the sharp folds this pressure has been completely overcome by the lateral pressure, but it has had undoubtedly much influence on the shape of the broad folds and the development of quartz.

This pressure accounts, no doubt, for the fact that large veins are seldom found between strata dipping at lower angles than forty or fifty degrees.

Moreover, on a broad fold, at the surface, important veins are found only at a certain distance from the anticlinal axis, and within a limited zone of strata, AB varying between 200 and 1,000 feet. That is to say, quartz veins were formed on a part CD of the fold, where the combined forces of the lateral and of the downward pressure have determined the greatest strain and have produced most sliding and fissures. The outer limit of the zone A, corresponds generally to a point at which the strata begin to dip at an angle which remains constant for some distance.

Likewise, in depth, quartz veins were formed on that part of the fold which was subjected to the same conditions, and is similarly situated. As the structure of a fold will not change much for some distance in depth, the extreme limits CD of the zone of quartz veins will be found at about the same distances from the anticlinal axis of the fold, that is to say, parallel with the axial line EF.

If the fold gets sharper in depth, the zone of quartz veins will approach the axial lines EF downward, and if it gets broader, the zone will recede from the axial line. The distance BE of the zone of quartz veins varies considerably in the different districts according to the flatness of the fold. The axial line EF may also coincide with BD in a sharper fold, and in a still sharper fold it may come half way between A and B, and we have then the typical saddle-reef fold.

Again, at the surface, in the same district, as at Goldenville, the fold may be sharper at one end and broader towards the other end, and in that case the zone of quartz veins will recede from the anticlinal axis, towards the broader end.

The quartz veins are sometimes very numerous on both sides of the anticlinal domes. On the Goldenville anticlinal dome, where developments have, perhaps, been more extensive than on any other districts in the province, some fifty-five different veins have been worked or uncovered, in a width of strata of 1,300 feet on the north side of the anticline, dipping north at forty-three degrees, and some fifty veins in a width of 500 feet on the south vertical dip of the anticline.

They extend in many cases on the surface for thousands of feet, and they have been mined to depths of 700 feet in their vertical extension.

The thickness of the veins varies considerably. The saddle-reef deposits are by far the heaviest bodies: those worked at Salmon River, Richardson and Mooseland mines attaining fifteen to twenty-five feet in thickness, and others not operated, at Fifteen-mile Stream, Cameron dam, &c., are probably larger.

The veins along the legs of the folds are much smaller, averaging from four inches to one foot, but often larger.

Many quartz veins are also found cutting the stratification at various angles; some are of great thickness, many are auriferous, and a few have been operated with notable profits. They are of later origin generally, than the interstratified veins, and some of them may be roughly contemporaneous with the intrusion of granite. Their richness is generally influenced by the nature of the adjacent strata.

In the interstratified veins the gold is sometimes distributed uniformly over considerable areas; usually, however, it is more or less concentrated within certain limits, leaving spaces on each side, comparatively barren. These enrichments are known as pay-streaks, and have hitherto been the principal source of the gold production.

Most pay-streaks are well defined enrichments of twenty to sixty feet in breadth, often accompanied by enlargement in the size of the vein. They dip at low, constant angles, parallel generally with the well-defined lines of schistosity of the rocks, and often with striations and corrugations on the walls, giving the veins a crumpled structure, locally called "barrel-quartz."

These corrugations and crumplings are more pronounced in the slate and quartz, and owe their origin to the sliding of thick beds of quartzite over one another, between which the softer bands curve and buckle in a wonderful manner. The pay-streaks lie at right angles to the sliding movement, that is to say, approximately parallel to the anticlinal axis.

Many of the pay-streaks have been proved very rich and some have been traced from the surface along a gentle incline for as much as 1,800 feet, with extraordinary uniformity. In many instances, two or three pay-streaks have been determined in the same vein lying parallel under one another for some distance. This mode of occurrence is necessarily limited to the portion of that vein situated in the pay-zone.

The laws governing the position and extent of the pay-ground or pay-streaks are intimately connected with the struct-

ure of the anticlinal folds and are similar to those already laid down for the position and extent of the zones of quartz veins. The data necessary to explain their many peculiarities in the different gold districts are difficult to obtain with any degree of precision, as few plans or records have been kept or are obtainable. As a general rule, the best pay-ground, in most districts, is situated at about the middle of the zone of quartz veins AB where fissures with angular-veins are most numerous. These small angular-veins or "angulars" which run into the walls at different angles, and sometimes connect one vein with the next, play an important part in the concentration or segregation of gold from the adjacent auriferous rocks, and, causing an enrichment or impoverishment of the main veins, they are well called locally "feeders" or "robbers."

In depth also, the zone of pay-ground GG should be situated at about the middle of the zone of quartz veins G, parallel with the axial line EF.

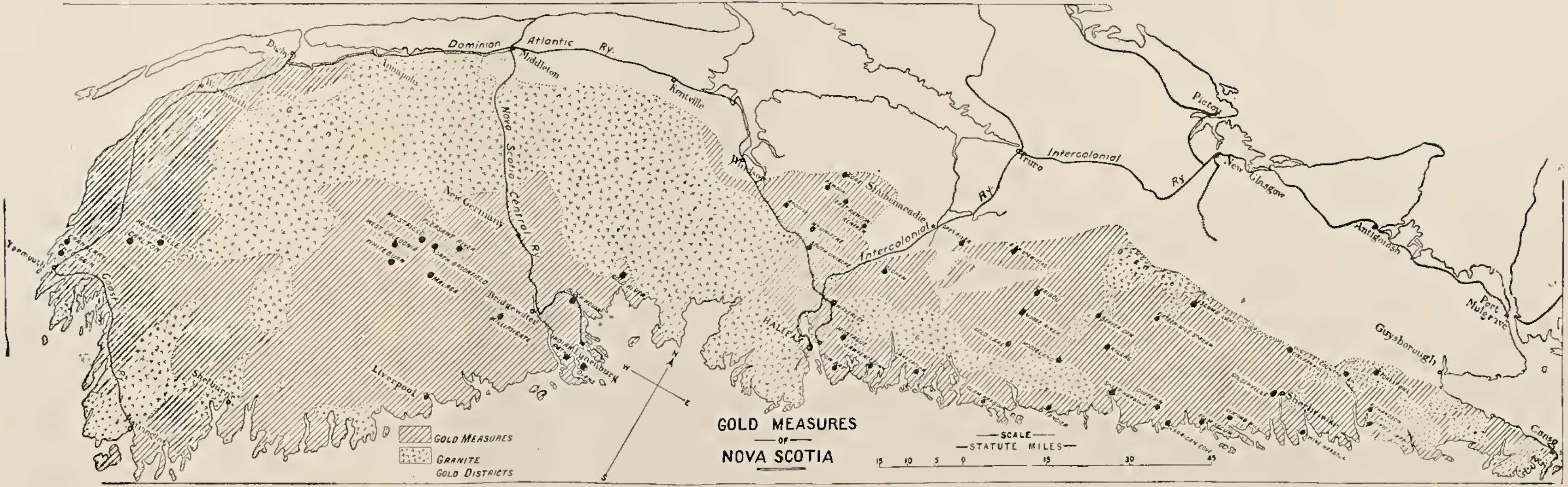
It will then be readily understood, that one individual vein, if it cannot hold gold in paying quantity to a great depth, may, nevertheless, be sufficiently rich to be worked with profit for a great length along certain lines parallel with the anticlinal axis: that a vein barren at the surface B may be rich in depth in the pay zone, and that a vein which does not come to the surface B may also be found payable on that pay zone G.

The problem then consists of developing a zone of pay-ground or portions of veins included within certain limits, along a plane GG, parallel with the axis EF, and that to depths practically unlimited.

This problem will, I am sure. prove interesting to mining engineers, and it only awaits their skill and knowledge to be put in practical operation and place the Nova Scotia gold-fields among the most productive in the world.

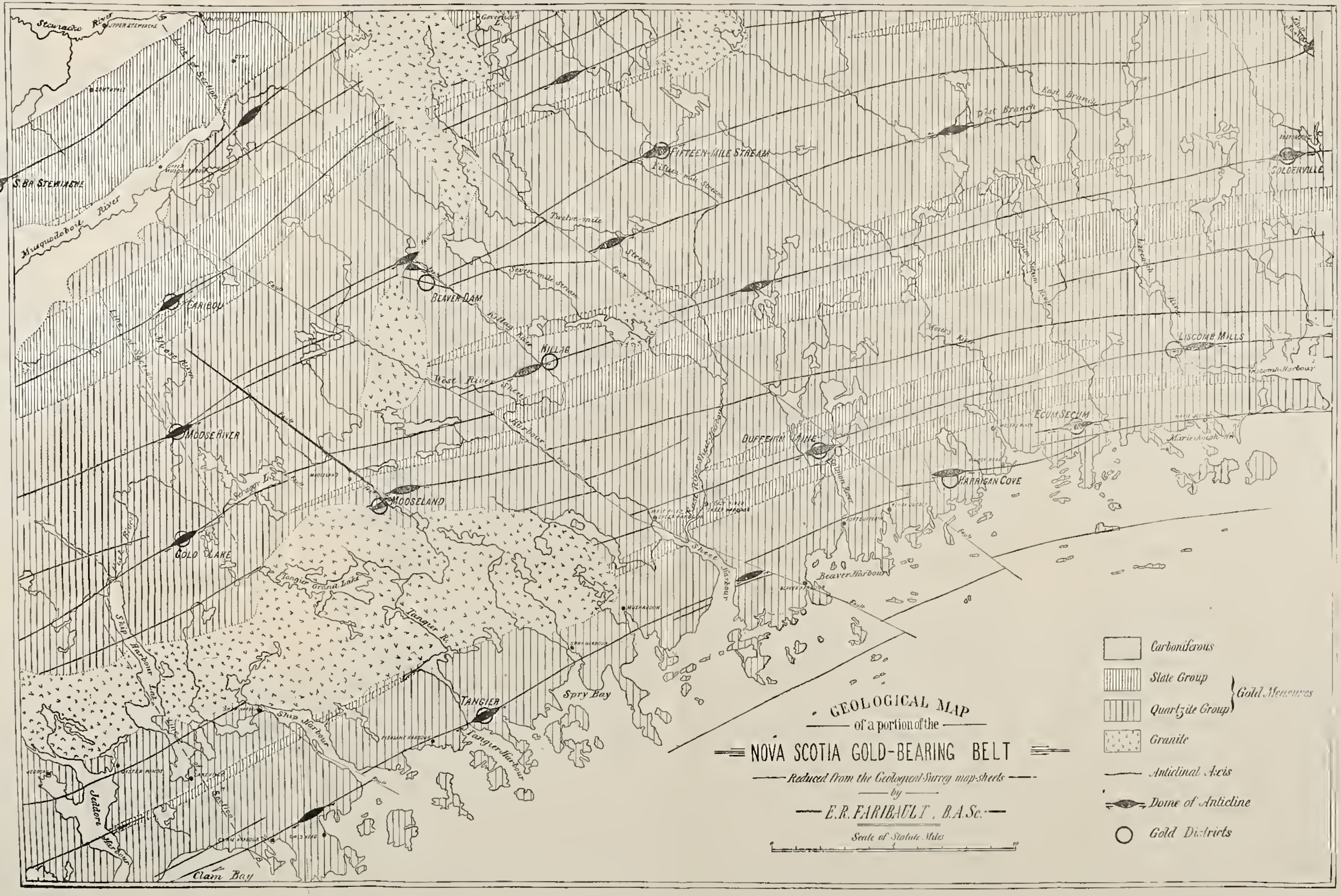
The Gold Measures of Nova Scotia and Deep Mining.

PLATE I.



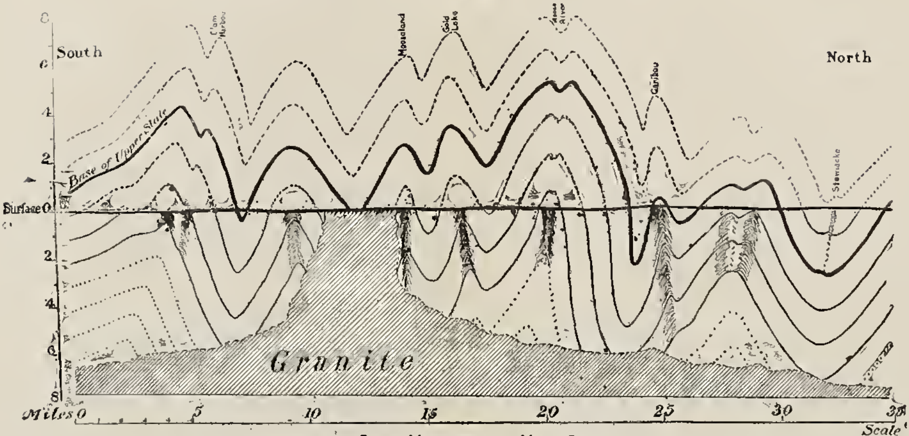
The Gold Measures of Nova Scotia and Deep Mining.

PLATE II.

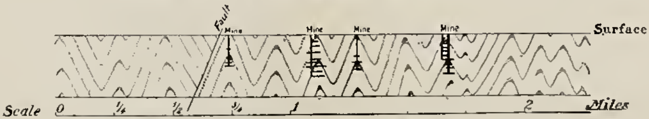


The Gold Measures of Nova Scotia and Deep Mining.

PLATE III.



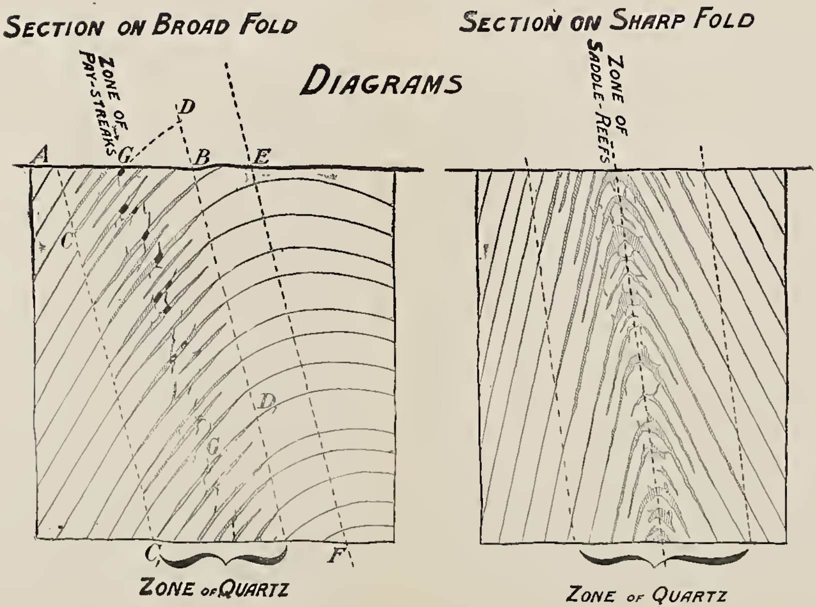
SECTION OF GOLD MEASURES IN NOVA SCOTIA.



SECTION OF BENDIGO GOLD-FIELD, AUSTRALIA.

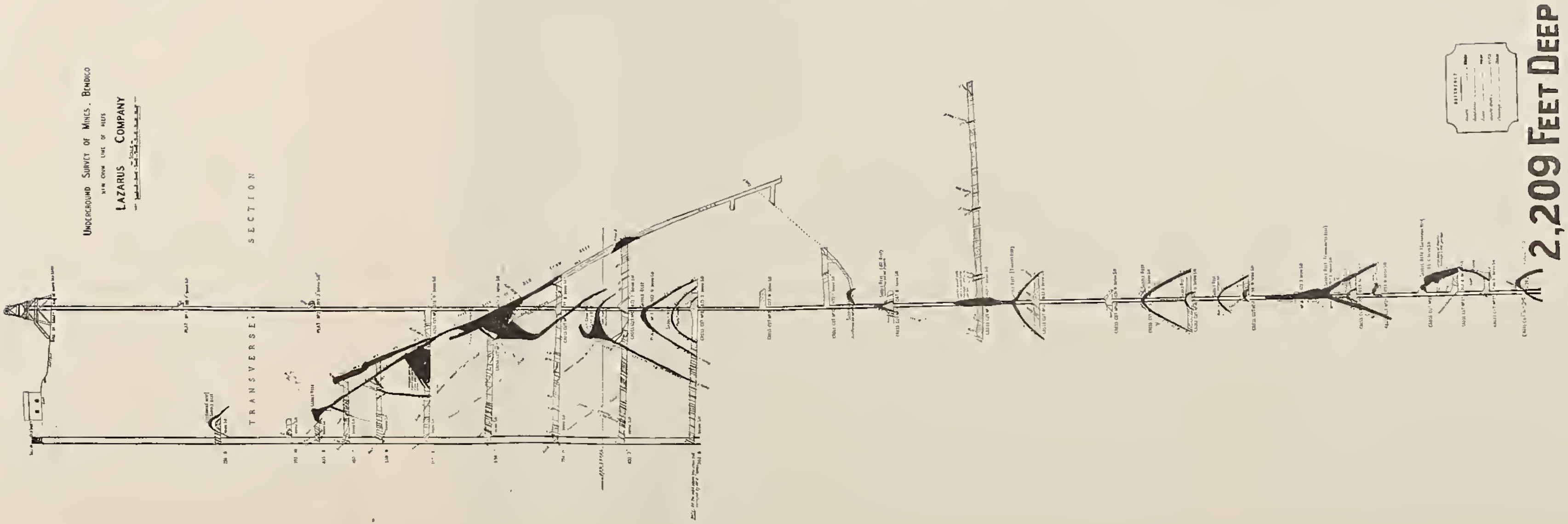
The Gold Measures of Nova Scotia and Deep Mining.

PLATES IV and V.



The Gold Measures of Nova Scotia and Deep Mining.

PLATE VI.



Extract

From Discussion at the Annual Meeting of the Canadian Mining Institute, March 1, 1899.

Mr. Andrews—I was quite interested in Mr. Faribault's comparison between the leads in Bendigo and the leads in Nova Scotia, especially with regard to their development in depth, and it was rather surprising to me to find that our leads compare so favorably with them. My limited experience has principally been in connection with some of the large bodies of ore in Nova Scotia, and particularly with those coming in close proximity to the anticlinal formation. I have watched Mr. Faribault explain all these formations, and I find that his conclusions coincide almost exactly with my own experience. For instance at the Richardson mine, at the time of the discovery of that reef, the anticlinal formation was not much of an accepted theory. The lead was first discovered on the south dip, and it was developed by tunneling eastward. The tunnel following the lead curved gradually northward, and then to the westward, forming a horse-shoe, proving that the vein was on the eastern pitch of a dome. One reason why at that place we were enabled to obtain our quartz so cheaply was on account of the location of our shaft house, which was eventually located at the turn, there already being a shaft dipping to the south-east; and after some expensive work, there were three shafts sunk on the turn of the anticlinal, all of which came to the surface at one big shaft house, so that all the rock was handled at the one place. The proper way to develop such a district, would be, as Mr. Faribault suggests, to sink a perpendicular shaft on the anticline through the lead or belt and carry it deeper to other saddle reefs lying one beneath the other in the same fold. I know there are a great many peo-

ple who are under the impression that mining operations in Australia are confined to one lead, whereas, as a matter of fact, the larger mines have extended their operations in depth to a number of leads; but after all then, the large and numerous saddle-reefs and veins, which have been worked to such great depths in Australia, would not be as extensive by one-twentieth as those likely to be met with in depth in the Nova Scotia formation. This fact in regard to mining in Nova Scotia is a matter of great encouragement. I, for one, though not born a Nova Scotian, but one who has spent a great deal of time there, believe that Mr. Faribault is deserving of a great deal of thanks for the work he has done in that Province.

Mr. Faribault—Mr. Andrews has just brought out a very interesting fact. In Bendigo the saddle-reef veins seldom extend more than 50 or 100 feet below the cap, while in Nova Scotia veins have been worked 700 feet in depth, and theoretically they should be about twenty times as extensive as in Bendigo, giving an extreme limit of 1,000 or 2,000 feet. There has been a tendency in Nova Scotia, on account of the great extent of the veins to confine the developments to individual veins, while in Bendigo the limited extent of the veins has led to development by means of perpendicular shafts and cross-cuts, new saddle veins being thus opened up one under another to depths of over 3,000 feet.

Mr. Douglas, President American Institute of Mining Engineers—My knowledge of gold mining in Nova Scotia is so perfunctory that I cannot form a conclusion with regard to it. This paper of Mr. Faribault's puts a new face upon the whole question. It will encourage those who have invested money in Nova Scotia and who have been discouraged by the work they have done, to extend their operations. It has determined me to point out to my friends the high and better hopes they ought to have, if they would only put back a little of the money they have already taken out.

Notes of the Mining of Low Grade Gold Ore in Nova Scotia.

By Mr. C. F. ANDREWS, Isaac's Harbour, N. S.

Read before the Canadian Mining Institute, February 3rd, 1897.

In view of the interest which at present is being awakened in the low grade gold ores of Nova Scotia, some personal observations in this line may not come amiss; the purpose of this paper is, therefore, to give an outline of some personal experiences while manager of the Richardson Mine at Isaac's Harbor, in the Province of Nova Scotia.

The writer does not for a moment claim that all the methods adopted during this experience have been at all times as satisfactory as he could have wished. Circumstances often compel us, when we cannot obtain that which we could desire, to accept that which of things obtainable, comes the nearest to meeting our wishes.

The Richardson belt is composed of slate and quartz, between regular walls of whin. It is located in what is known as Stormont Gold District as the Gold Brook Anti-clinal (also called the Upper Seal Harbor Anti-clinal) the course of which is N. 62° W. and S. 62° E.; and along which auriferous belts, lodes and drift have been discovered for a distance of three miles.

The Richardson belt was first discovered and worked on its south dip, where the average width was 11½ feet. In working west the belt narrowed down considerably. Eastward the belt turned in a northerly direction increased in width to 18 feet and lay very flat, the dip changing from south to east; continuing, it swung around and ran westwardly, assuming a north dip and growing smaller again than on the turn.

The mill for crushing this ore is located about three hundred

yards from the mine on the shore of a lake, from which the water supply is obtained. The ore is conveyed from the mine in cars running over steel rails, laid the greater part of the distance on trestle work. These cars are hauled by means of a steel cable, the power being taken from the mill. The total expense for haulage averages about three cents per ton, including renewals of cars, ropes, wheels, axles, &c.

When first started the mill was furnished with but fifteen stamps: a few months later the number was increased to twenty, and later to forty.

The following extracts from a report of the directors in June, 1894, may be of interest, it being remembered that the mill then consisted of twenty stamps with hand-breaking and feeding:—

"At the mine three shafts have been sunk. The west shaft is not more than 30 feet deep and was put down mainly to test the length of the belt, which is here about seven feet wide.

"The middle shaft is down 100 feet, width of belt here from eight to fourteen feet. Tunnels and stopes are driven west from here 72 feet or to a point within eighteen feet of the west shaft."

The labor expenses here for drilling and blasting amounted to 26 cents per ton. The cost of dynamite per ton of ore sent to mill was $3\frac{1}{2}$ cents.

"Tunnels and stopes are also driven east from here to connect with the east shaft, which is 108 feet deep. The southerly dip of the middle shaft is about 52° from the horizontal, that of the east shaft about 42°. East of the east shaft a tunnel has been driven on the belt 89 feet, the belt at this point having a width of $17\frac{1}{2}$ feet. Here a bend of 70 to the northward takes place in the course of the belt. A tunnel has been driven here on the belt for a distance of 85 feet, the dip being 23° in an easterly direction, the width 18 feet."

The total cost for mining, transporting to mill, and milling at this time was $2.90 per ton, including an allowance for total depreciation in value of plant in five years, and for taxes, insurance and all charges.

"The belt for the most part is composed of one large lode on the back-wall side, varying in width from one to four feet, and a varying number of small lodes intermixed with slate. At places nearly the entire belt is quartz, and gold is sometimes found in the soft slate between the lodes. Not enough black or waste rock can be obtained below to load the scaffolds; and the walls have to be supported by leaving blocks or pillars of ore."

It may be stated here that the underhand method of stoping was employed. In an attempt to use the overhand method it was found that the slate between the veins of quartz was not firm and solid enough to hold the quartz in place overhead, and consequently, large masses of rock were falling, making it dangerous to the miners beneath. I am of opinion that at greater depth the slate becomes more firm and solid, and overhand stoping may be resorted to.

At this time hoisting was done from the east and middle shafts by a single cylinder engine, geared to a single friction-drum. The gear was so located that the rope could be shifted from one shaft to the other, as occasion required. Wheelbarrows were used below ground as a means of transporting the ore to the shaft; and the ore was then hoisted in tubs to the surface, where it was washed, the waste rock thrown out, and the good ore shovelled into cars to be hauled to the mill.

Since then the belt has been followed farther west on the south dip; the east shaft, now the pump shaft sunk to a depth of 200 feet, and the belt driven and stoped on around the turn and followed west on the north dip. At the time of writing the belt produces more waste slate than in 1894.

The present plan consists of a hoisting, pump and breaking gear, located on the apex of the semi-cone formed by the turn of the belt. Two shafts are worked from here, one on the south dip and one on the north. The bottoms of these shafts are about 250 feet apart, as measured on the belt around the turn; and as they are sunk this distance is of course increasing. At the surface they are 48 feet apart and converging towards each other. At a height of twenty-six feet above the surface the skip-tracks

from each meet above the same deck head; and self-dumping skips empty their loads beside the same rock-breaker. The "sump" at the deck-head into which the skips dump their loads is lined on the bottom with open-sand cast iron plates $\frac{7}{8}$ inch thick, laid in $\frac{5}{8}$ inch of cement. The ore is here thoroughly washed, the waste rock thrown into trolleys and run out on the dumps, and the good ore shovelled into a hopper which drops it between the jaws of a 9 x 15″ Blake breaker, from which it falls into a bin. Cars are run under the bins where the ore is allowed to fall into them. They are then run out on the main track and hauled by the wire cable to the mill, where they are dumped into a bin of 500 tons capacity. Thence the ore runs through shoots into the automatic feeders supplying the mortars. Copper plates are used inside these mortars. The surface dimensions of the outside plates are 12 ft. 6 in. x 4 ft. After passing over the outside plates and through mercury traps, the sand is discarded: no attempt being made at concentration.

In the mine every attention has been paid to working the rock to the greatest advantage. On account of the dip to the seams in the belt, it has been found that two drills working toward the west accomplish as much as three drills working towards the east. The works below are now supplied with a regular system of tracks over which the ore is conveyed in trolleys to the electric-lighted loading stages at the shafts. The south shaft, being the main shaft, is supplied with two skip tracks, one for the east and one for the west ore. The pump way is between the skip tracks and a little below them, or nearer the foot wall: thus being out of the way when ore is being loaded into the skips or timber being unloaded from them. The ladder-way is a compartment by itself cribbed up under the foot-wall cribbing, where it passes through the surface material, thus being out of the way of anything which could fall or injure a man. The slope of the shaft is so flat that no ladder is required to get at the pump. The north shaft has a skip-way in the east end and a ladder-way in the west end. The stopes were started from the east side of the south shaft and carried round to the

north shaft—this rock being hoisted from the south shaft. The stopes are then continued west beyond the north shaft and the ore hoisted from the north shaft. Thus while ore has been hoisted from both shafts, the sinking and expenses connected therewith have been confined to one shaft. The number of hand-drills employed here to produce 2000 tons of crushing ore per month has never exceeded nine—two men to a drill. The surface plant at the mine consists of a 60 h.p. tubular boiler set in brick, and a 50 h.p. compound engine set on concrete foundation. Floors of engine and boiler rooms are of concrete. The hoisting machine is a double drum one, built especially by the Jenckes Machine Co., and laid on a concrete foundation. The drums are side by side and of the usual cone friction type; but instead of being driven by two small cylinders attached to it, its driving shaft is driven by belt and pulley from the compound engine: the same engine serving to drive the pumping gear and the rock breaker. The experience here has been that it is far more economical to drive everything from one compound engine than from a number of smaller ones, particularly where all machines are working continually day and night. The engineer fires his own boiler, and no extra attendance is required for the hoisting machines. Thus, the deckman when not engaged in bringing up or lowering skips, can wash and assort ores.

The water from the mine pump is discharged into a tank under a hatch in the peak of the roof. A hose from this serves for washing quartz or for fire purposes. The building is heated by exhaust steam from the engine, and like the mill, forge, workshop, stables, office, manager's house, etc., is lighted by electricity.

At the mill the plant consists of forty 850 lb. stamps, two return tubular boilers, one 16 x 42 Corliss engine, one Worthington duplex steam pump, $3\frac{1}{2}$ inch suction and 3″ discharge, one Northey pump of the same description, a dynamo for lighting purposes, and the hauling gear for bringing the ore from the mine. The forty stamps are arranged in a row, and the ore bin

extends the full length of the batteries.

The ore cars enter the building at right angles to the ore bin, are turned on a table and run along the top of the bin to be dumped wherever the ore may be most required. One mortar is reserved for test purposes, the bin in front of it having a partition to keep the test ore separate from the regular ore.

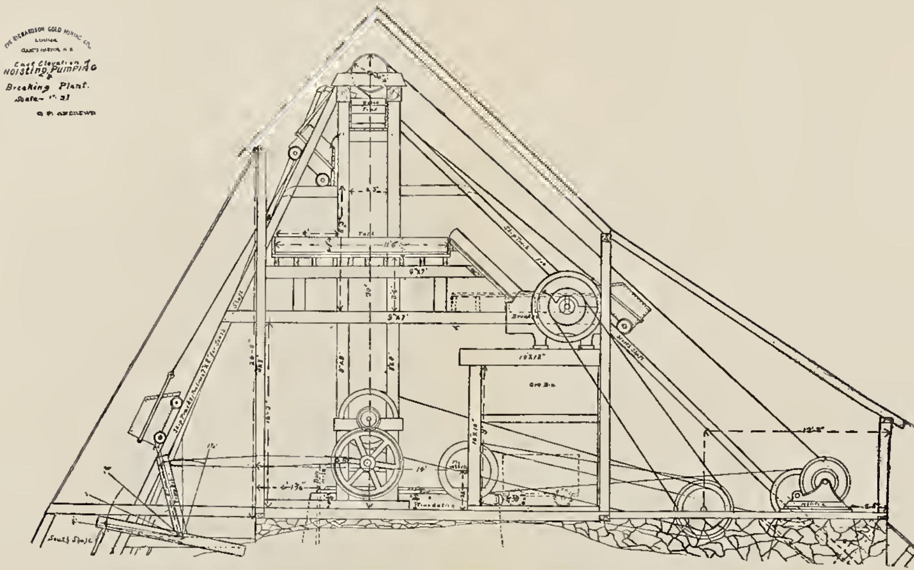
The stamps drop 90 times per minute, and the mortars are arranged for very fine crushing. At times the gold is so fine as to be indiscernible to the naked eye. An instance of this was when 4,000 tons of ore were milled in which not a colour of gold was seen, but which, when cleaned up, gave a fair profit

With this plant up to the time when my connection with the mine ceased, the total cost for mining and milling, including all charges, was $1.65 per ton.

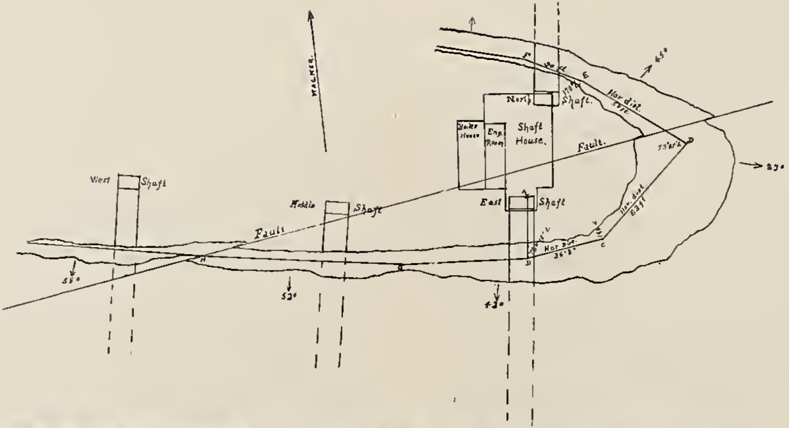
At the mill but one engineer was employed on each twelve hour shift, it being also his duty to attend to the dynamo and lights. It may be interesting to know that the electric light plant installed here paid for itself in one year in the saving of kerosene oil alone. When there is power to spare, as was the case here, and a large number of lights required, it cannot be too highly recommended, particularly around the plates of a mill.

The Richardson belt is very heavily mineralized: and there is great cause for regret that only the free gold is saved. The results of a careful and elaborate series of tests of the tailings from this mine made by Mr. F. H. Mason, are somewhat surprising to many who do not consider the auriferous ores of Nova Scotia worth concentration. But facts speak loudly for themselves, and, much as we would like to have all of our ore free milling, this desire does not alter the refractory nature of some of it.

According to these tests made when the ore being crushed was of an unusually low grade, the average loss was 1 dwt. 18 gr. per ton. A sample of tailings from which all the concentrates were not extracted gave 1.3% of concentrates, which had an assay value of 1 oz. 10 dwt. 1 gr. per ton, and still left a value of 1 dwt. per ton in the tailings. Another sample



Richardson Gold Mining Company—Hoisting, Pumping, and Breaking Plant.



Plan Showing Richardson Belt east turn Gold Brook Anti-clinal, also location of Shaft House.

Horizontal Distance A to B, 30 ft. 8 inches
Vertical Distance " 45 ft. 2 "
C. D. E. F. = Points in Roof.
Arrow head = Direction of Dip.

ple of tailings gave 6.3% of sandy concentrates, having an assay value of 1 oz. 1 dwt. 13 gr. per ton of concentrates. In neither sample was free gold or amalgam detected. The majority of the arsenical iron pyrites is contained in the slate; some samples of this slate assay very high. A chance sample gave the surprising result of 28 oz. 8 dwt. of gold to the ton of concentrates and yielded 30% of its total weight in concentrates. Two more assays of this slate gave concentrates valued respectively at 4 oz. 2 dwt. 8 grs. and 5 oz. 6 dwt. 12 grs. per standard ton of concentrates. As this slate contains so little free gold but a small portion of it is crushed.*

An analysis of clear concentrates taken from the sluices of the mill gave the following composition:—

Silica	2·65
Iron	35·63
Sulphur	16·80
Arsenic	42·25
Copper	trace
Bismuth	"
Zinc	"
Mercury	nil

An assay of these concentrates gave gold 2 oz. 14 dwt. 21 gr. per ton. A chlorination test of these concentrates obtained an extraction of 97% of gold contained.

Being myself present when Mr. Mason made a great many of his tests and assays, and knowing the care that was taken with them, I cannot help feeling that it would be of general interest to those interested in gold mining in Nova Scotia to quote from Mr. Mason's report as follows:—

" It will be seen that you are losing a considerable amount of refractory gold in your tailings, you are dumping a consider-

* Near the surface the slate is soft and partially decomposed. In this condition it yields considerable free gold when milled. As the depth increases the slate becomes harder, increasing perceptibly in bulk and in the quantity and quality of its concentrates. Below a depth of about 100 feet it contains so little free gold that it is unprofitable as a free milling ore.

able quantity of auriferous slate and leaving a further and larger quantity in the mine, and finally you have a large tailing dump, parts of which would pay handsomely for working over. I am satisfied that the gold you are losing in your tailings is practically all in the form of concentrates. In churning up an ore (often heavily charged with mispickle) in the battery, you must of necessity at times flour a certain quantity of mercury: added to this, owing to the quantity of slate you are finely crushing, you have a very slimy tailings, consequently the floured mercury has little chance of re-settling, and small quantities are at times found to be carried away with your tailings. * *

"With a view to saving the refractory gold, I would strongly advise you to put it in Frue vanners, use a coarse mesh screen, and cut down discharge to one-half what it is at present. I would also increase the stamping capacity by increasing the number of drops from ninety, at which you are now running your mill, to one hundred drops a minute. In advising you to do this, I wish to bring the following advantages you will gain to your notice:—

1. "You will be able to crush the whole belt, for your slate certainly contains refractory gold, and at times free milling gold. Your mine superintendent told me that he estimated that not more than one-third of the rock broken underground was milled, so at the present time you are paying for breaking rock 66% of which you have not in the past milled, nor would I advise you to mill it unless you put in concentrators, and crush it only coarsely, for it is highly refractory, and if crushed finely, it will flour mercury, and in that way probably carry away more gold than it would contribute to the amalgam in the battery and on the plates."

2. "You will decrease your mining expenses by more than one-half: the only extra expense will be in hauling part of the slate, and in winding and hauling the remainder, while your output will be nearly three times what it is at present."

3. "I am of opinion that the slate will provide enough free

gold to pay for the milling, in which case the concentrates will be all clear profit."

4. "You will dispense with the cost of picking the ore. I estimate that the cost of Frue vanners erected in Nova Scotia will be about $150.00 per stamp. To get satisfactory concentration it will also be necessary for you to put in mechanical sizers, (the cost of which is small) and feed the coarse tailings on to one set of vanners and the fine on to another set."

"Having obtained your concentrates, chlorination is undoubtedly the method by which they should be treated. The cost of such treatment in Nova Scotia will, I estimate, be about $4.00 per ton of concentrates. It will also be a matter for consideration whether the arsenic will be worth saving, for two reasons—firstly, for its value, which is doubtful: and secondly, to prevent its contaminating pasture lands, and consequently prevent claims against you for poisoning cattle."

"The cost of an eight or ten ton chlorination plant erected in Nova Scotia will be about $3,000, exclusive of building."

Up to the present time this property has produced 43,000 tons of ore, which goes to show that the mining of low grade ores in Nova Scotia at a reasonable cost per ton, has got beyond the experimental stages and is a reality. The handling of the refractory ores has yet to be experimented with, and from the appearance of nearly all the ore I have seen along the Gold Group anti-clinal, I am of opinion that material for the experiment is not lacking.

Additional Notes by the Author.

The cost per ton given in this article as $1.65, is based on an estimate for dry ton. The actual weight of this ton, as it came from the mine, was 2400 lbs., making the cost for producing a twenty hundred weight ton of wet or natural ore $1.37½. I would state also, that at this time the average width of belt that was mined was about 12 feet. One half of this ore was sent to

the mill, consequently, the cost of \$1.37½ for producing a ton of ore in its natural state, also covered the cost of producing another ton of ore, which, on account of its refractory nature and lack of proper machines for handling, was either thrown on the waste dump or put on the scaffolds in the mine.

Regarding the concentrates, subsequent developments since the date of this paper have proved that their value has been fully up to what I had expected of them. The paper states that 43,000 tons of ore had been mined at that date. Since then, these figures have been increased to about 115,000 tons.

C. F. A.

Mining and Milling Costs at the Brookfield Mine, Queens Co., N. S.

By W. L. LIBBEY, President Brookfield Mining Company.

During six months, from May 1st to November 1st, 1897, 5606 tons of ore were sent to the mill, at an average cost of $2.54 per ton, as follows, for ore landed at the rock-breaker :—

Labor (which includes blacksmiths and deck men)	$11,173 99
Timber and Poles	392 40
Shovels	35 20
Picks	20 60
Blacksmith's Coal, 6 tons, @ $10.66	63 96
Charcoal, 300 bushels, @ 15c	45 00
Axes	5 00
Hoisting Ropes (estimated)	50 00
Candles	364 29
Loss of Steel	71 82
Fuel (Pumping Station and Mill)	1,046 00
Explosives	654 75
Iron (including Rails for Tracks)	126 70
Miscellaneous Expenses	125 00
Lumber	45 00
	$14,219 71

All of this work was done with hand drills and by underhand stoping.

We next give three months' work with air drills. The three months taken are January, February and March, 1898, during which time 2,840 tons of ore were sent to the mill at an average cost of $2.44 per ton, as follows, for ore landed at rock-breaker :—

Labor (which includes Blacksmiths and deck men)	$5,078 95
Timber and Poles	198 80
Shovels	10 00
Picks	12 00
Blacksmith's Coal, $4\frac{1}{2}$ tons, @ $10.66	47 97
Charcoal, 150 Bushels, @ 15c	22 50
Hoisting Ropes	25 00
Candles	171 00
Loss in Steel	11 25
Fuel at Pumping Station and Mill	717 00
Explosives	512 50
Iron (including Rails for Tracks)	43 45
Miscellaneous Expenses	75 00
Lumber	25 00
	$6,950 42

The result thus far was apparently to place our ore at the deck head ten cents per ton cheaper with an air plant than by hand work. We were, however, doing more than 25% more of sinking and drifting with the air plant. In fact, it would be impossible to place men enough in the mine to equal by hand the work done by power.

These tables cover all cost of development work.

Following is a table showing the expenses of running the 20-stamp mill for six months, commencing Sept. 1st, 1897, and ending Feb. 28th, 1898. During this time 5,910 tons of ore were milled and concentrated at an average cost of 63 cents:—

Fuel	876 00
Labor—2 Firemen	360 00
" 3 Amalgamators	900 00
" 2 Concentrator Boys	420 00
" 1 Carpenter	242 00
" 1 Engineer	300 00
Miscellaneous Expenses, including Lubricants	75 00
Cost total for Shoes and Dies	397 53
Mercury lost, $79\frac{1}{4}$ lbs., @ 60c	47 55
Screen Wire, 192 feet, @ 50c	96 00
Total	$3,714 73

We now give a record for two months of work done with Rand Slugger Drills. The character of our country rock being quartzite and so tough and hard that we probably could not live with hand drills at all.

The increase of labor in drilling and the amount of explosives necessary to use being marked as we get deeper, the depth now being about 650 feet.

Drill Work for Months of January and February, 1900.

Days Drilled, $278\frac{3}{4}$.
Feet " 7318.
Average feet per day per man, 26.29

Cost of Explosives	441	75
Cost of Drills and Helpers	829	81
	$1271	56

Average cost per day	$ 11	09	
Total Cost of Labor and Explosives for Foot Drilled	17	37	cents.

Measurements of ore displaced and the mill records of ore crushed, shows that the vein has averaged nearly two and one-half feet of crushing material.

Extracts from Paper Entitled

Rapid Sinking in a Nova Scotia Gold Mine.

By A. A. HAYWARD.

Read before the Mining Society of Nova Scotia.

On the property owned by the Golden Lode Mining Company it was pretty well determined there existed a rich gold strike, but that such strike would be deep and consequently expensive to reach. After a careful survey it was found that if this strike was to be developed it would be necessary to sink a shaft 403 feet through hard country rock composed of quartzite, and as this lode was not accompanied by a belt, as is usually the case in mines of this Province, the shaft would have to be blasted out of the solid rock. When the depth to be sunk and the nature of the rock, together with many other disadvantages that were found to exist, were fully considered, the outlook seemed discouraging. It was a new departure, to sink a shaft 403 feet through hard barren rock to determine the continuity of a gold strike, and was something a little removed from the hitherto gold mining practice in this Province.

During the month of January, the necessary buildings were erected in which were located the machinery necessary to perform the required work; in the engine house was located a small 35 horse-power locomotive boiler, also a small high speed winding engine. Over the shaft, a distance of 125 feet from the engine house, was erected a hoisting tower in which was constructed a ventilating tower 50 feet in height, which in reality was an extension of the eastern compartment of the shaft up through the hoisting tower and 30 feet above it. As steam was employed as a motive force used in operating two Rand No. 2 rock drills, this ventilator was an absolute necessity, as it supplied cool

and fresh air to the shaft and carried away the exhaust steam from the drills.

The shaft was divided into two compartments, each being 4 x 4 inside, requiring rock dimensions of $5\frac{1}{2}$ x 12 feet.

Before beginning operations a model of the shaft was made, and into this model was inserted pegs which represented the position of each and every hole that was to be drilled and their direction. The drill men were fully instructed as to the duty each hole was expected to perform, and were also instructed to put down the holes each day, as shown on the model, irrespective of the seams or slips that might occur in the shafts.

The underground work was divided into three shifts of eight hours each. The first and drilling shift began at 7 a.m. and consisted of a foreman, two drill men and two helpers. The men in this shift were expected to drill all necessary holes, and to have the work completed before three o'clock, which time they rarely exceeded, as most of the drilling operations were completed before one o'clock ; the drills, tools and piping were then hoisted to the surface, leaving the shaft ready for blasting. The second shift, which began at three o'clock, consisted of two muckers and a firing boss, whose duty it was to measure the depth of each and every hole, keep a record of the same, also keep a record of the amount of explosive used in each and every hole. This firing boss remained on sixteen hours, and had charge of both the second and third shifts. The records kept by him of the work performed in each shift were recorded in the office at the end of each shift in a book kept for that purpose. This shift was expected to fire the four sump holes and to clean up the same during their eight hours.

The third and last shift, which consisted of but two muckers, were expected to fire all the remaining holes, clean up the rock, quarry any loose rock in the bottom of the shaft, put in new slides and do any necessary timbering, and leave the shaft ready for the drilling shift, which came on again at seven.

On the surface the shifts were divided into two 12 hours

each. The first shift consisted of engineer, deck man, blacksmith and carpenter. The second shift comprised but two men, the engineer and deck man. The deck man in each shift was required to tally the amount of water and rock hoisted in his shift; the engineer also recorded the amount of fuel used each day, which with the other records were recorded in the office at the end of each shift, so that from a perusal of the records it was possible without going into the mine to approximately tell how fast the shaft was being sunk. and what cost per foot.

When the shaft reached a depth of fifty feet, sinking was suspended and timbering begun. The shifts were then divided into two of 12 hours each.

The first shift cut three hitches in the rock, put in three timbers 12 x 12, and bolted down the heads. Upon these hitch timbers was constructed eight feet of crib work, the timber having previously been prepared by the carpenter. The timber used in this crib work was hewn from green logs, they being found the most suitable to withstand the heavy blasting. From the top of this crib to the timber above, stulls were placed in the shaft, and on these was spiked 2 inch plank, which formed the dividing.

The duty of the second timbering shift was to bring down new and permanent slides, new ladders, bring down the main steam pipe and to place a heavy platform over one-half of this crib which was used as a station. This work was expected to be completed in 24 hours from the time of beginning. The shaft was then ready for sinking again. The hitches referred to were always cut 12 feet from the bottom. As three feet was found to be about the average sinking done per day, the steam pipe used below this station was cut into sections of three feet each, one piece being added each day. By this means the steam hose was always suspended in the shaft and not under foot.

The drill men each day after coming out of the shaft, took their machines apart, cleaned them thoroughly inside and out, added new parts when required, put in new packing, and kept

them up to a standard, so that no delays were occasioned by drills being out of order.

During the month of April the work was performed with but one machine only, which sunk 55 feet 6 inches.

During the entire operation the total number of days occupied in drilling was 124, timbering 16, making in all 140 days required to sink and timber the shaft 403 feet. The average sinking was found to be 3.02 per shift, although five feet was in several instances recorded.

The following is a record of the work performed each month:—

MONTH.	Drilling.	Timbering.	Number of Holes.	Feet.	Explosive.	Buckets of Rock.	Feet Sunk.
April	20	4	134	482	201	861	55.6
May	24	2	241	941	365	1,249	75.2
June	19	4	182	714	316	1,077	73.8
July	23	2	231	981	324	1,323	69.6
August	23	3	240	953	450	1,393	85.0
September	15	3	147	657	236	949	44.2
	124	18	1,175	4,728	1,892	6,852	403.0

The average sinking, as will be seen, was 3.02 per day of 24 hours, while the amount of explosive used per foot is found to be 4.06 pounds per foot of shaft-sinking, or $1.22 per foot, which includes detonators, connecting wire and so forth. The average monthly sinking was 71 feet 6 inches. During the month of August 85 feet was sunk, being the best work performed during the operation.

The total cost of the shaft, which includes management, office expenses, labor, fuel, timber, repairs of tools, and all expenses chargeable to the shaft, was $4,647, or $11.53 per foot, completed and timbered ready for permanent occupancy.

During the summer of 1897 the shaft of the Golden Group Mine was sunk 100 feet below the 240 foot level. The time required to sink this shaft was 30 shifts, and had it not been found necessary to save the small rich lode on the foot wall, this 100 feet would have been accomplished in 25 days.

I am not at present in a position to give the exact cost of this work; it was, however, somewhat in excess of the cost of sinking the shaft of the Golden Lode Mine. The same methods were, however, employed, and the same division of labor, showing that what could be done in one place can be done again under the same conditions and management.

References.

The Reports of the Nova Scotia Inspectors of Mines from 1861.

The Reports of the Department of Public Works and Mines to date, with contemporary papers and references in the Statistical and Annual Summaries in the Reports of the Geological Survey of Canada.

List of Reports of the Gold-bearing Rocks. Several of the principal gold districts of the Province have been studied minutely and reported upon by different authorities, and more especially by Dr. A. R. C. Selwyn, Dr. T. Sterry Hunt, Dr. B. Silliman, Prof. H. Youle Hind, and Messrs. John Campbell, Henry Poole, A. Heatherington and H. S. Poole.

The following list of reports and pamphlets relating to the lower Cambrian Rocks and the gold districts, given in chronological order, may be of use to those interested in the study of them :—

Gesner.—Remarks on the Geology and Mineralogy of Nova Scotia, 1836 ; The Industrial Resources of Nova Scotia, 1849 ; Gold Fields of Nova Scotia, 1862 ; Gold and its Separation from other Minerals, 1836, Trans. N. S. Inst. Nat. Sc., Vol. 1, Part I, Page 54.

Dawson.—Metamorphic and Metalliferous Rocks of the Atlantic Coast of Nova Scotia, 1850, in the Journal of the Geological Society of London, Vol. VI., Pp. 347–364 ; On the Recent Discoveries of Gold in Nova Scotia, 1861, in the Canadian Naturalist, Vol. VI, Page 417 ;

Acadian Geology, 1855, Second Edition, 1868, and Supplement, 1878.

Marsh.—The Gold of Nova Scotia, 1861, Amer. Journal of Science and Arts, Vol. XXXII.

Honeyman.—Geology of the Gold Fields of Nova Scotia, 1862, Quarterly Jour. Geol. Soc., Vol. XVIII, Page 342; Report on Gay's River Gold Fields, 1866, Trans. N. S. Inst. of Nat. Sc, Vol. II, Part I, Page 76; Micro-Polariscopic Investigation of the Crystaline Rocks of the Gold Bearing Series of Yarmouth, N. S., 1882, ditto, Vol VI., Page 7; Geology of Halifax and Colchester Counties, 1883, ditto, Page 52. Other Notes by the same author are scattered through the Trans. N. S. Inst. of Nat. Sc.

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Hunt.—Gold Region of Nova Scotia, 1868, Report of Geological Survey of Canada; On the Geology of Eastern New England and N. S., 1870, Amer. Jour. Sc. (2), L., Pages 87 and 133.

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Waverly and Sherbrooke, 1870: Report on Mount Uniacke, Oldham and Renfrew Mining Districts, with Plans and Sections, 1872; Report on the Indian Path Gold Mine of Lunenburg District, 1873.

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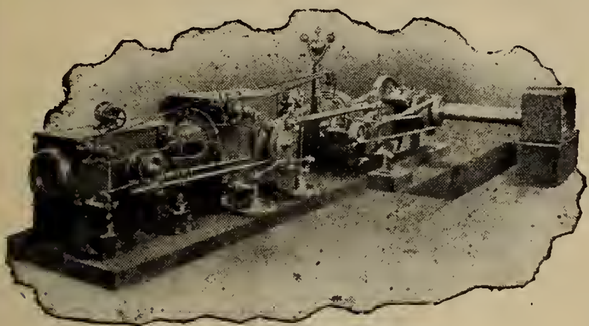

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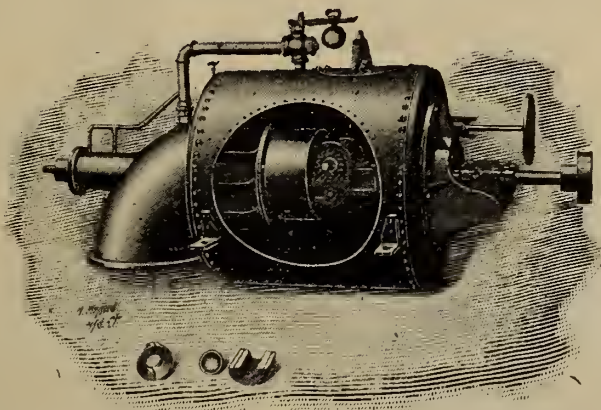

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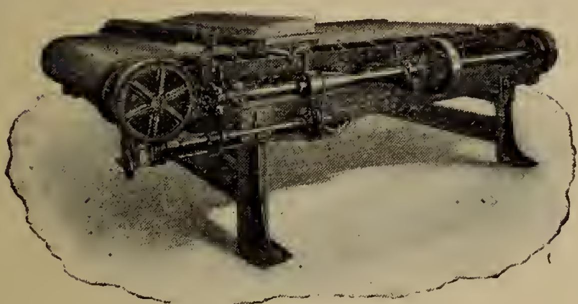

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